INDIAN TEA ASSOCIATION.

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT 1947.

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1. CHIEF SCIENTIFIC OFFICER'S REPORT.

1. Staff.

At the beginning of the year the senior staff at Tocklai consisted of :—

Mr. C. J. Harrison	...	Chief Scientific Officer
Mr. A. C. Tunstall	...	Mycologist
Mr. N. M. Macgregor	...	Senior Advisory Officer
Dr. W. Wight	...	Botanist
Dr. E. K. Woodford	...	Agriculturist
Mr. E. J. Winter	...	Advisory Officer Surma Valley
Mr. E. Hainsworth	...	Officiating Entomologist
Mr. N. G. Gokhale	...	Soil & Analytical Chemist
Dr. E. A. H. Roberts	...	Bio-chemist

Dr. Roberts was in the U. K., on leave and working on Tea Biochemistry at Oxford. Mr. D. J. Wood was appointed as Biochemist in September after completing studies at Cambridge and before joining Dr. Roberts at Oxford.

Mr. S. K. Dutta joined the Department as Agriculturist on 1st August.

Of the above staff I regret to announce that by the time this Report appears Mr. A. C. Tunstall will have retired after 36 years service and Messrs. Macgregor and Woodford will also have left the Station having resigned, the former for family reasons, and the latter to take up an appointment at Oxford University. I offer on behalf of the whole of the Tocklai staff our very good wishes for the future to the three Officers who are leaving us.

Three new officers have accepted appointments on the staff of the Scientific Department and are expected to join during the early part of 1948. These are Dr. G. M. Das, Entomologist, to join in January, Messrs. R. I. Macalpine (Advisory Officer Darjeeling & Terai), and P. M. Glover (Advisory Officer Surma Valley), both of whom are to join in June.

2. Buildings and Equipment.

Owing to shortage of building materials and difficulties of transport, progress in repairs and reconstruction was not as great as was hoped. The following statement gives the position at the end of 1947.

Building	Progress 1947.	Further work required.
Main Office Library and Lecture Room.	Building complete Library reorganised	Re-organisation of Office.
Chemical Building.	Main structure completed.	Minor reconstruction Equipment of Biochemical Department. *
Botanical Building.	Repairs completed	—
Agricultural.	Repairs completed	—
Pathological.	Repairs partly completed.	Insectary to be constructed, reconstruction of Mycological section.
Factory and Power House.	—	New engine to be installed Batteries renovated. Factory and machinery to be renovated & reorganised.
Main Stores Godown	Newly built	—
Guest House	Structurally repaired	To be furnished. Sanitary and electric fittings to be completed. Complete refurnishing. Servant houses. to be repaired.
Dispensary	Completed	—
Bungalow A	—	To be divided into two separate bachelor's quarters.
Bungalow B	—	Minor repairs.
Bungalow 1	Completed	
Bungalow 2	Partly repaired	Further repairs
Bungalow 3	Partly repaired	Further repairs
Bungalow 4	Repairs complete	
Bungalow 5	—	Further minor repairs
Bungalow 6	—	Further minor repairs
Bungalow 7	—	—

In addition to the above, line houses will need repairing and new quarters built. Owing to inability to obtain building materials at present, much of this work will of necessity be of temporary nature.

* When Tea Biochemistry and Manufacture work is in full swing it will require the whole of the Chemistry Building, and a new building will need to be erected to house the Analytical and Soil Branch.

3. Health.

The health of the senior staff was unusually bad during the year : of the total of 16 members, wives and families, only four were not ill, while 8 were in hospital for varying periods. It is to be hoped that this year is the exception which proves the rule. The health of the junior staff and labour was generally average. In future, Paludrine will be given prophylactically to all members of senior and junior staff and labour, and there will be monthly spraying of all domestic buildings with DDT.

4. Publications.

The following publications were issued during the year.

Memorandum No. 6. "Nitrogen Supply to Tea" by H. R. Copper (Revised edition).

„ No. 16. "Stem diseases of tea in North East India" by A. C. Tunstall and K. C. Sarma.

„ No. 17. "Improvement of Milk Supplies on Tea Estates" By C. J. Harrison and N. M. Macgregor.

„ No. 18. "Purification of Tea Estate Water Supplies" by C. J. Harrison.

„ No. 20. "The Utilisation of Waste land" by N. M. Macgregor and S. C. Dutta.

Tea Protection Pamphlet No. 1 - Life cycle of the Looper caterpillar.
Proceedings of the Fifth Annual Conference.
Annual Report 1946.
Twelve Serials of the Tea Encyclopaedia were published.

During the year two questionnaires were circulated and the response was most gratifying. One was concerned with the incidence of Looper caterpillar in Tea in North East India, and the other with Red Spider in the Surma Valley.

The publication of Serials was held up owing to non-arrival of the paper ordered from U. K. This has now arrived and it is hoped to produce 3 Serials per month.

It has been arranged that in future all Scientific Department publications will be distributed from Tocklai direct to members. All communications regarding Scientific Department publications should therefore be addressed to the Chief Scientific Officer, Tocklai Experimental Station, Cinnamara P. O., Assam.

(5). Translation of foreign scientific literature : Acknowledgment.

Recently Mr. & Mrs. Hill of Mohokutie Tea Estate have translated certain Dutch articles from Java which are of special interest to us. These translations are excellent and are of the greatest value to us and to the industry in North East India. I take this opportunity of acknowledging our great indebtedness and thanks to Mr. & Mrs. Hill.

(6). Touring.

A list of the tours carried out by the various Officers during 1947 is given in the Appendix B.

(7). Visit of Chairman Indian Tea Association Calcutta, and Members of London Advisory Committee.

On December 5th and 6th Mr. R. L. Hards, Mr. A. N. Stuart and Mr. E. J. Nicholls (members of the London Advisory Committee) visited this Station and later Mr. J. M. Kilburn (Member of London Advisory Committee and of the Engledow Committee which investigated and reported on the activities of the Station in 1936). The Chief Scientific Officer during his visits to the U. K. in 1945 and in 1947, had formed the opinion that there was an impression in London that the best results were not being obtained from the work of the Scientific Department. It was therefore a matter for satisfaction to all members of the staff that these gentlemen made a thorough inspection of the activities of the Scientific Department and were satisfied that the Department was working efficiently and giving full value to the industry.

(8). Botanical Exploration.

During 1947 the Scientific Department was fortunate in securing the services of Capt. F. Kingdon-Ward in (a) making a collection of Camellia spp. and allied genera growing in the Khasi Hills and, (b) investigating the habitats and distribution of Camellia sinensis in North Assam.

Reports of both investigations have already been submitted to the Calcutta and London Committees.

Capt. Kingdon-Ward will continue investigations on behalf of the Industry during 1948.

C. J Harrison.
Chief Scientific Officer.

II ADVISORY.

(1). Surma Valley Branch.

Mr. Winter, (Surma Valley Branch Advisory Officer) reopened the Surma Valley Branch after a lapse of six years, at the beginning of January. A laboratory was reequipped and staffed for general routine work, and Mr. Winter carried out frequent tours of the Surma Valley estates throughout the year.

Three pamphlets entitled "Quarterly Observations" were compiled and circulated to all Surma Valley tea concerns. These contained a general account of the advisory and experimental work in progress, together with observations of a practical nature made during tours.

In conjunction with the Pathological Branch, Tocklai, extensive observations on Helopeltis attack, followed by experiments on its control, using DDT preparations, were made. The results of these experiments have been embodied in a pamphlet issued by the Scientific Department.

A questionnaire on Red Spider in the Surma Valley met with good response from Tea Estate Managers. and the results are to be collated and made public in a Memorandum.

(2). Field Experiments.

(a). Manuring and leguminous shade trees. Both in the Surma Valley and in other districts of North East India field experiments are in progress on many commercial estates. The most important of these, in the plains, are concerned with the effects of nitrogenous fertilisers under shade trees (leguminous). It is as yet too early to draw definite conclusions from this set of experiments but indications are that, as was suspected, little or no benefit in increased crop is derived from applying nitrogenous fertiliser to high yielding tea under heavy leguminous shade trees.

(b). Bulk organic vs inorganic fertilisers. A field trial in which the effect of annual applications of cattle manure and sulphate of ammonia on the yield of tea are compared, has been in progress since 1933. The soil is very sandy and well drained. Cattle manure was applied each year at 200 maunds per acre, supplying on average about 80 lbs. nitrogen per acre. The cost in 1947 including application was Rs. 20/- per acre. Sulphate of ammonia was applied at 200 lbs. per acre, supplying 40 lbs. nitrogen at all in cost of Rs. 40/- per acre in 1947. In pre-war days, before the cost of artificials had soared to its present level, the cost of applying 40 lbs. nitrogen as sulphate of ammonia was about Rs. 20/- all in compared with about Rs. 10/- for 200 mds. cattle manure

As the following table shows, the artificial has always given a greater crop than the bulk organic until 1947 when yields were identical.

Year.	Difference. mds. per acre.	Year.	Difference. mds per acre.
1933	0·06	1941	1·72
1934	0·36	1942	1·38
1935	0·48	1943	1·56
1936	0·33	1944	0·98
1937	0·56	1945	0·41
1938	0·84	1946	0·88
1939	0·88	1947	0·00
1940	1·07		

In 1945 we suspected that some error had crept in and in 1946 were not surprised to see the curve going up again. The 1947 results however leave little doubt that some rational explanation must be found for the relative increase in yield from the cattle manure plots since 1942.

Potash and Phosphate were omitted from the artificial fertiliser plots in 1944, 1945 and 1946 but were applied again in 1947, yet they apparently did no good in that year and their absence cannot easily be held to account for the further drop in crop in 1947.

There is always the chance that the residual effect of the cattle manure has been piling up all these years but it would hardly take as long as 10 years to show an appreciable effect.

The possibility of trace elements too has to be considered but their absence is extremely unlikely to be the cause for the ultimate gain made by the plots manured with cattle manure.

(c). Experiments in Darjeeling. Two field trials were started on Margarets Hope Tea Estate, one in 1939 to compare different pruning cycles, and one in 1940 to determine the effect of nitrogen, potash and phosphate singly and in combination, on yield and quality.

In both experiments the tea was very poor, typical of a very large proportion of tea at the higher elevations of the district.

In the pruning experiment four systems were compared—

1. Annually pruned and plucked level above a new growth of 7 inches.
2. Pruned every alternate year : tipped to 8" above the pruning and plucked level (unpruned in alternate years).
3. Pruned every third year, plucked as for (2).
4. Pruned every fourth year, plucked as for (2).

The results of this experiment for the eight years 1940 to 1947 have been worked out by averaging the figures for the complete cycles.

Annual prune	...	...	8 cycles.
Biennial prune	...	...	4 cycles.
Quadrennial prune	...	...	2 cycles.

In the case of the triennial prune which required 3, 6 or 9 years for a complete number of cycles the yields in the 3rd and 6th year have been averaged and that figure taken to represent the 9th year.

In this way the mean annual crop for the four types of prune are :

Annual	mean	annual	yield	...	...	1·99	mds/acre.
Biennial	"	"	"	...	...	2·75	"
Triennial	"	"	"	...	...	3·14	"
Quadrennnial	"	"	"	...	...	3·22	"

Any differences between treatment yields exceediug 0·27 mds. may be considered significant.

We cannot therefore regard the quadrennial prune as being definitely preferable to the triennial. On the other hand it is no worse and there are two things in its favour.

1. It is cheaper not to prune than to prune.
2. By leaving unpruned in the fourth year one is enabled to make more quality spring teas.

The yields are however very low indeed, and even in the Darjeeling district such poor yielding tea is hardly likely to pay in future.

The manuring experiment is on similar low yielding tea, under a 4-year pruning cycle.

The manures were applied annually to give 60 lbs. nitrogen per acre as sulphate of ammonia, and 30 lbs. each of potash and phosphoric acid per acre, applied as muriate of potash and superphosphate respectively.

The average yields for the years 1940-47 inclusive, for the eight different combinations of manure are—

Manure.	mds/acre	Manure.	mds/acre
No manure	1·75	Nitrogen only	3·24
Potash only	1·90	N and potash	4·10
Phosphate only	1·94	N and phosphate	3·08
Potash & Phosphate	1·84	N + P + K	4·10
Average for no nitrogen	1·86	Average for 60 lbs. nitrogen	3·63

Taking one pruning cycle of 4 years, i. e. 1943-1946 inclusive, there is a mean increase of 2·2 mds. made tea per acre from the use of 60 lbs. nitrogen. This is less than half that obtained on plains gardens.

During 1946 and 1947, leaf from the 8 different manurial treatments was manufactured separately on 7 occasions, and the teas reported on by a Calcutta broker. The following table gives the order of preference given by the broker to the tea samples.

Order of merit of teas manufactured in 1946/47.
(1 = placed first).

Manuring	1946			1947				Average order of preference.
	5/9	13/9	10/10	20/5	18/6	5/8	4/11	
Nil	6	8	4	7	3	1	8	5·3
P	4	3	7	6	4	4	7	5·0
K	5	4	3	8	2	3	5	4·3
PK	2	2	1	2	8	2	6	3·6
N	1	1	6	5	1	5	1	5·0
NP	4	5	5	4	7	6	4	4·4
NK	4	7	2	3	6	7	2	2·9
NPK	3	6	4	1	5	8	3	4·3

Summing up the values we get — Potash — 3·8
Nitrogen — 4·2
Phosphate — 4·3

A further comparison is of interest

Single dressings i. e. Nil, N. P. and K	Dressing involving interactions NP. NK, PK and NPK
4·9	3·8

Both tables put up a case for manuring, and the second in particular puts up a case for balanced mixtures.

These results are of particular interest to Darjeeling, showing as they do that crops can be greatly increased by nitrogenous fertilisers, without loss of quality, particularly if " balanced " mixtures are used.

(3). The use of weed-killers in tea and on grazing lands.

Considerable publicity has been given to the fact that certain of the auxins can be used as selective weed-killers when applied in sufficient quantity, varying (according to the literature) between $\frac{1}{2}$ to 6 lbs. per acre. Success has been reported from the use of the proprietory substance Methoxone, in other countries, and in India ; In the latter case, particularly in its lethal effect on water hyacinth in Bengal.

The weeds to which these substances prove most fatal are mostly of the di-cotyledon type, corn and grasses being relatively unaffected. It is clear therefore that they can be little or no use to the tea industry so far as the main crop is concerned. Grazing land however is an adjunct to most tea gardens and, unless over-grazed, is liable to infestation by weeds, particularly Melastoma and Eupatorium species. Although with constant supervision large areas can be kept clean by hand at very moderate expense, it is seldom that this is done, and it was thought that if one application of Methoxone were effective in suppressing these weeds its simple application might well justify the increased cost.

In our experiments 2 methyl 4 chloro phenoxy acetic acid in the proprietory form known as 10 % Methoxone was applied to grazing land in quantities representing 6, 2 and $\frac{2}{3}$ lbs. per acre of the pure substance.

The plots to which it was applied carried mature plants of *Melastoma Malabathricum* and *Eupatorium Odoratum*, both of which after methoxone treatment, showed the typical curling of the stalks and, later, rooting on the stems, but even on those plots which received the highest application, over 90 % of the plants recovered and were none the worse 3 months later.

The application of the substance was found however to have greatly reduced the number of seedlings growing on the plots 3 months after application, even when applied at less than 1 lb. per acre.

There is reason to believe that applications of 1 lb. of methoxone applied in 100 to 200 gallons of water to grazing and thatch land immediately after burning off, or to the unburnt areas early in the spring, will greatly reduce infestation by weeds.

We are indebted to Imperial Chemical Industries (India) Ltd. for the sample of 10 % Methoxone used in these experiments.

It is of greater interest and importance to the tea industry to obtain a substance which will destroy grasses, rather than dicotyledonous plants. The difficulty of keeping green crops from being smothered, in the early stages, by more rapidly growing grass weeds, is well known among planters.

Certain of the unsaturated petroleum oil distillates have been tested and found to have a selective action on grasses, and are likely to prove of commercial value in this respect, as they are relatively cheap.

Two oils, one called " M.T.R. Oil " and the other " Mineral Turpentine, " samples of which were supplied to us by Messrs. Burmah Oil Co. Ltd., Digboi, were tested on rows of young boga medeloa at Tocklai. The medeloa was 8 weeks old, about 18" high and already infested with a considerable amount of grass.

The mineral turpentine proved more effective than the MTR Oil.

The area on which the oil has been used, being ploughed up grazing land, is however not truly representative of tea garden areas and carries a different population of grasses. It is possible to carry out these experiments at one period only in the year, and they will be repeated in tea areas next year now that the required rate of application is known approximately.

It is doubtful however whether the cost of the oil will not prohibit its use in tea.

When medeloa is planted in alternate rows of tea there are approximately 1800 running yards of bed to the acre. To cover one acre requires 15 gallons of oil per acre, as a minimum dose

At a cost of say Rs. 1 4 per gallon or Rs. 20 - per acre, the use of oil might prove just worth while, for although the beds can be hand weeded for about Rs. 6/4 - per acre, labour is often scarce at the time of the year when the weeding has to be done.

Two ways in which the dosage might be reduced are—

1. Using a finer spray.
2. Using divided doses.

The only use which can be seen at present for grass-killing oils in tea is for the suppression of thatch etc. in young medeloa. For drives and footpaths however, where areas are small, cost is negligible and hand weeding for one reason or another difficult and undesirable. both M. T. R. oil and Mineral Turpentine may be of value.

C. J. Harrison,
(i c Advisory.)

III AGRICULTURAL.

(A) FIELD EXPERIMENTS AT BORBHETTA.

1. Shade Trees.

Different types of shade trees :

Area 1 A of 6 acres, which was planted with one year old Khorijan plants in November 1939, has now seven different types of shade trees.

This area had a very bad Red spider attack and plucking was lifted by 2" i. e., from 8" to 10". This has caused a drop in crop, but this drop varies according to the type of the shade tree and the drop is highest where there is no shade, indicating that shade is associated with less Red spider. The types of shade trees that give highest increase in crop also indicate the least loss due to Red spider attack.

The indication will be seen in the crop yield figures for 1946 and 1947.

Shade	Yields mds. per acre. 1946	1947	Decrease.
Albizzia Stipulata (Red sau)	20·46	18·46	2·0
,, Stipulata (Green sau)	20·60	18·82	1·78
,, Procera (Koroi)	19·20	17·02	2·18
Aleurites Montana (Tung)	18·77	16·76	2·01
Dalbergia Assamica (Bormedeloa)	19·74	16·73	3·01
Derris Robusta	19·74	16·89	2·85
Albizzia Odoratissima	20·59	18·92	1·67
No shade tree	19·74	16·24	3·50

It will be noticed from the above figures that tea under Albizzia Odoratissima, Albizzia Stipulata (Green) and Albizzia Stipulata (Red) are giving the highest yields. It can also be seen that the drops in yield of tea under these trees are also the least. The tea without any shade trees is showing the poorest yield and the Aleurites Montana, Dalbergia Assamica and Derris Robusta are not proving much better up to date. Albizzia Stipulata (Red) has given significantly higher yield than Dalbergia Assamica and no shade tree ; Albizzia Stipulata (Green) and Albizzia Odoratissima have given signifantly higher yield than Albizzia Procera, Aleurites Montana, Dalbergia Assamica, Derris Robusta and no shade tree.

2. Effect of Shade and Nitrogenous manuring.

Area 45 47 of Borbhetta was planted up $4\frac{1}{2}' \times 4\frac{1}{2}'$ triangular with one-year old tea plants of 12 different jats, in October 1936. The area is divided up into six blocks with 2 sub-blocks in each. Each sub-block has 12 plots. One sub-block of each block is shaded and the plots carry 100 bushes with a Sau tree in the middle of each plot in the shaded sub-blocks i. e. $45' \times 45'$ triangular. These were planted in April 1937. Six plots in each sub-block are manured with nitrogenous manure.

Thus the treatments are as follows —

36 plots have manure and no shade	...	(+ M - S)
36 plots have manure and shade	...	(+ M + S)
36 plots have no manure and no shade	...	(- M - S)
36 plots have no manure but have shade	...	(- M + S)

Manuring in the manured plots and pruning in all plots has been as follows :—

	Manuring.	Pruning.
1937—	60 lbs. N. as S. O. A.	No pruning
1938—	60 lbs. N. as S. O. A. 20 lbs. P. as Superphosphate 20 lbs. K. as Sulphate of potash	Cut across at 18" from ground.
1939—	60 lbs. N. 20 lbs. P. 80 lbs. K as above	18" from ground.
1940—	60 lbs. N. 20 lbs. P. 30 lbs. K. as above	19" from ground.
1941—	80 lbs. N. as Oilcake	20" from ground.
1942—	80 lbs. N. as Oilcake	½" new wood.
1943—	60 lbs. N. as S. O. A.	½" new wood.
1944—	60 lbs. N. as S. O. A.	½" new wood.
1945—	60 lbs. N. as S. O. A.	½" new wood.
1946—	100 lbs. N. as S. O. A.	½" new wood.
1947—	100 lbs. N. as S. O. A. 40 lbs. P. as Superphosphate 40 lbs. K. as Muriate of potash	½" new wood.

The effects of manure and shade have been uniform all through and crop yield figures for 1947 are given below—

Effects of Nitrogen × Shade on crop.
Mds. made tea per acre in 1947.

	− N	+ N	Mean.
− S	7·05	14·39	10·72
+ S	15·85	19·91	17·88
Mean	11·45	17·15	14·30

From the table it is seen that increase due to manuring alone is 7·3 mds per acre and increase due to shade alone is 8·8 mds. per acre. But the interaction between Shade and Manuring is negative although the crop is considerably increased i. e. by 12·86 mds.

Increase by shade in unmanured plots	...	8·80 mds.
Increase by manure in unshaded plots	...	7·34 „
Increase by shade in manured plots	...	5·52 „
Increase by manure in shaded plots	...	4·06 „
Increase by manure and shade	....	12·86 „

In this area, shade alone is proving of more benefit than manure alone, and as usual, the efficiency of nitrogen as sulphate of ammonia is decreased under such moderate shade as is provided by good Sau trees 45' × 45' apart.

In these days of shortage of manure, shade is of more importance than ever. A good stand of Sau shade trees can be maintained by judicious replanting when the trees become mature and show signs of dying back. Replanting should be done in such a way that the old trees can be left till the newly planted ones are providing sufficient shade i. e. about 4 years old. Albizzia Odoratissima, which has so far remained free from canker at Borbhetta, should not present the same difficulties.

In the case of Sau trees one may estimate its effective life at a maximum of 16 years. In some districts 12 years can be regarded as its maximum effective life.

3. N. P. K. Manures and Dark and Light Leaf jats.

Area 7 was planted 4½' × 4½' triangular in 1935; half the area Silbhetta light leaf (Betjan once removed) and half with Silbhetta dark leaf (Dhalai once removed) plants. This tea has been manured since 1936 with inorganic manures only; nitrogen, potash and phosphoric acid at 3 levels, except in 1945, when no P or K were applied, as these were not available.

The yields in maunds tea per acre since 1938 are given below :—

(a) Nett effect of all treatments on dark and light leaf considered separately,

	YEAR									
Treatments	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Light Leaf	1·18	5·09	6·30	9·45	13·17	12·40	10·08	10·30	12·04	14·42
Dark Leaf	0·87	4·07	5·31	8·06	12·03	11·38	9·14	9·90	11·30	12·83
Sig. Difference	·10	·21	0·27	0·28	0·32	0·16	0·34	0·35	0·38	0·53

(b) Separate effect of different treatments on dark and light leaf considered together.

20 lbs. Nitro.	1·03	4·27	5·08	8·07	11·54	10·74	8·68	9·01	9·74	11·96
60 lbs. „	1·02	4·89	6·54	9·43	13·66	13·05	10·54	11·19	13·60	15·26
Sig Difference	·10	·21	0·27	0·28	0·32	0·16	0·34	0·35	0·38	0·53
No, Potash	0·90	4·02	5·32	8·23	12·26	11·76	9·47	10·40	11·88	13·54
20 lbs. Potash	0·99	4·57	5·90	8·73	12·69	11·97	9·83	10·03	11·54	13·95
60 lbs. Potash	1·21	5·17	6·72	9·38	12·97	11·96	9·61	9·95	11·70	13·38
Sig. Difference	·12	·26	0·34	0·34	0·45	0·20	0·42	0·43	0·46	0·64
No. Phos. acid	0·96	4·44	5·71	8·31	11·95	11·08	9·12	9·63	10·95	12·26
20lbs. Phos. „	1·04	4·64	6·01	8·94	12·85	12·15	9·72	10·38	11·97	14·28
60lbs. Phos „	1·07	4·68	6·24	9·10	13·11	12·46	10·07	10·37	12·20	14·33
Sig Difference	·12	·26	0·34	0·34	0·45	0·20	0·42	0·43	0·46	0·64
Number of Plucking rounds	22	36	35	34	36	32	23	29	31	35

Differences in nitrogen dressings made no difference to the young crop in 1938, but in 1939, the bushes attained sufficient size to make use of the nitrogen and gave increased yield - 60 lbs. nitrogen giving significantly higher crop than the bushes getting 20 lbs. nitrogen. In each year after 1939, a highly significant difference has been maintained between the two levels of nitrogen.

The effect of potash remained highly significant till 1941, i. e. till the tea was 7 years old, but from 1942, there has been no significant increase in crop from potash. No potash was applied in 1945, and in that year, yields of plots receiving potash in previous years were lower and kept low in 1946, when potash was applied again.

Phosphoric acid made no difference to crop for the first three years of plucking, i. e. till 1940. In 1941, the difference was significant and this difference has been maintained till 1947. The results however show that the extra yield obtained from 60 lbs. of phosphoric acid as against 20 lbs. phosphoric acid has never been significant except in 1943, but even here the difference was negligible. In 1945 when no phosphoric acid was applied, the bushes receiving 60 lbs. phosphoric acid in the previous years, gave 0·01 md. made tea less than the bushes that were receiving 20 lbs. phosphoric acid in the previous years. When phosphoric acid was applied again in 1946, the yield increased by 1·02 mds. for 20 lbs. (which was significant), but no significant increase was obtained from an extra 40 lbs. of phosphoric acid. As can be seen from the table, the increase in yield in 1947 for 20 lbs. of phosphoric acid has been 2 mds. per acre, which certainly is of considerable economic importance.

In the early years, before the bushes were covering the soil, phosphoric acid increased greatly the weed growth - especially of a creeping grass *Paspalum Sanguinale*. Quoting from the Annual Report 1940.

> "Weighments of weed growth in June, after plots had not been hoed for 3 weeks, showed that no phosphoric acid resulted in a growth amounting to less than a ton per acre ; 20 lbs. phosphoric acid increased the weed growth by $2\frac{1}{4}$ tons, while 60 lbs. increased it by over 3 tons".
>
> "In spite of continual hoeing the plots treated with phosphoric acid are always somewhat 'dirty' - and this in itself must be retarding growth of the tea. What the crop increase from phosphoric acid might have been if weed growth had been really efficiently suppressed is difficult to estimate, but it is thought it might have been very considerable".

When the bushes reached a stage when they were covering the soil and thereby suppressing weed growth, the beneficial effect of the phosphoric acid on the tea,—previously masked by the harmful effect of excessive weed growth,-became apparent, and has persisted up to the present time.

Nitrogen and Jat interaction has been significant in 1943, 1944, 1946 and 1947. In these years the light leaf jat made more use of the nitrogenous manure than did the dark leaf jat.

Nitrogen and phosphoric acid interaction has been significant so far in 1938, 1940, 1941, 1942, 1943 and 1946. That is, in these years, nitrogen applied with phosphate gave significantly more crop than nitrogen applied alone.

No other reactions have been significant since 1943, when N × K, Jat × K and Jat × P showed significance. The most important interaction is that of nitrogen and phosphoric acid.

In 1947, Red spider had attacked this area and observations were made on this attack. It was found that Red spider was more severe on the plots receiving larger doses of nitrogen. There was also significantly more severe attack by Red spider on plots receiving phosphoric acid, but the two higher levels of phosphoric acid did not differ significantly.

This area was planted up with shade trees in March 1947, and growth of the shade trees in relation to manuring and the effect of N.P.K. on tea under shade is being observed. Till the end of 1947, there has been no significant difference in the growth of the trees under different treatments.

3. Small effect of Phosphoric manures, on tea crop.

In area 40 of Borbhetta, interesting results are being obtained from application of Superphosphate, even in very low levels of 15 lbs. of phosphoric acid per acre. This increase is significant only if the phosphoric acid is applied to tea under shade. The tea in the shaded plots of this area is shaded with Sau trees planted in the middle of each plot of 90 bushes planted $4\frac{1}{2}'$ × $4\frac{1}{2}'$ thus the Sau trees are planted $40\frac{1}{2}'$ × 45 ft. These trees were planted in 1941.

The following table shows the crop figures for the last three years in maunds.

	1945				1946				1947			
	Phosphoric acid				Phosphoric acid				Phosphoric acid			
	0 lb	15 lb	30 lb	60 lb	0 lb	15 lb	30 lb	60 lb	0 lb	15 lb	30 lb	60 lb
Unshaded	11·80	11·60	11·8	11·3	7·6	7·3	7·6	7·5	6·9	6·7	6·9	6·9
Shaded	12·9	13·9	13·8	13·7	9·7	10·9	11·1	10·9	7·4	8·6	8·2	8·3

It will be seen from the above figures that the application of 15 lbs. of phosphoric acid to tea without shade has no effect at all, but when this dose is applied to tea with shade, there is an increase of at least a maund of made tea per acre. Higher doses of phosphoric acid than 15 lbs per acre have not so far increased crop in this area.

4. Effect of P. K. Manures and Shade on the growth of Boga medeloa.

Area 40 of Borbhetta was medium pruned in November 1946. In order to shade these medium pruned bushes, the sides were pruned in January 1946 and the area was sown with Boga medeloa in alternate rows.

The growth of the Boga medeloa was observed in all plots receiving different doses of P. and K. manures and also under shade and without shade.

In November 1947, the Boga medeloa plants were cut down and the centre row of each plot was weighed carefully after cutting.

The weights (in lbs.) of Boga medeloa under different treatments have been as follows :—

(P) Phosphate × (K) Potash.

	P_0 lb.	P_{15}lb.	P_{30}lb.	P_{60}lb.	Total
K 0 lb.	92	121	118	135	466
K 15 lb.	123	131	121	138	513
K 30 lb.	107	133	118	138	496
K 60 lb.	93	131	128	138	490
	415	416	485	549	1965

Sig. Diff. between levels of P = 61·0

Sig. Diff. between levels of K = 62·9

(K) Potash × Shade.

	K_0 lb.	K_{15}lb.	K_{30}lb.	K_{60}lb.	Total
—Shade	305	371	336	332	1344
+Shade	161	142	160	158	621
	466	513	496	490	1965

Sig. Diff. between shade = 206·4

Sig. Diff. between K = 62·9

(P) Phosphate × Shade.

	P_0 lb.	P_{15}lb.	P_{30}lb.	P_{60}lb.	Total
—Shade	258	358	357	371	1344
+Shade	157	158	128	178	621
	415	516	485	549	1965

Sig. Diff. between shade = 206·6

Sig. Diff. between levels of P = 62·9

	P 0 lb.		P 15 lb.		P 30 lb.		P 60 lb.		
	−S	+S	−S	+S	−S	+S	−S	+S	
K 0 lb	49	43	84	37	82	36	90	45	466
K 15 lb.	85	38	93	38	95	26	98	40	513
K 30 lb.	63	44	92	41	88	30	93	45	496
K 60 lb.	61	32	89	42	92	36	90	48	490
Total	258	157	358	158	357	128	371	178	1965

It will be seen from the above tables that shade is highly detrimental to the growth of Boga medoloa, but it is interesting to note that phosphatic manures significantly increase the growth of Boga medeloa even with a very small dose of 15 pounds, when this crop is not under shade. Potash manures however, have little effect on the growth of Boga medeloa, both with and without shade.

Tephrosia candida is mainly a green crop, but it is also a shade. It has been found that it is a good crop for covering the soil prior to planting and during the first few years of the life of the tea bush. The main effect of this crop is not so much the addition of organic matter but in creating a suitable environment for the young tea and reducing the soil temperature and loss of moisture ; and increasing atmospheric humidity and the rate of nitrification in the soil.

When Boga medeloa is grown in young tea 4 to 6 years old, i. e. before the tea bushes have a permanent cover, it reduces crop while it is standing, but there is every evidence to prove that the final effect on crop is beneficial, after the green crop has been returned to the soil.

The effect of Boga medeloa is influenced by presence of manure, as even 60 lbs. of nitrogen in the form of Sulphate of ammonia gives less crop with uncut Boga medeloa than by itself. This effect is similar to that obtained in mature tea when it is under shade. Boga medeloa has very little depressing effect on mature tea.

It was found that Arhar (*Cajanus indicus*) definitely reduces yield of tea, while the Arhar crop is growing. This reduction is proportional to the growth of the Arhar crop. Yield of tea however, increases when it is cut down and more than outweighs the losses sustained when the Arhar crop is growing.

Attempts should be made to grow Arhar in mixture with Boga medeloa (Arhar and Boga medeloa in alternate rows) and leaving the Arhar crop till the seeds are ripe for collection for Dal, after which the plant is cut down, leaving the alternate rows of Boga medeloa standing. The rows that had Arhar should be sown with Boga medeloa in the following year. Thus in the second year one can have 1-year and 2-year old Boga medeloa in alternate rows.

Actually an 'semi-permanent' green crop which fixes nitrogen and will grow on an acid soil without the addition of lime, is probably always beneficial in young tea before it covers the soil.

Crotalaria anagyroides is being tried out as a green crop. It is a much faster growing crop than *Tephrosia candida*, but its stems are brittle and weak, and it has a shallower root system tending to cause the plant to lodge badly. Trials carried out during the year by spacing and lopping at different heights, have convinced us that it is not as satisfactory a crop as *Tephrosia candida* for use as a temporary shade, but that it is probably the more satisfactory

green crop in Tea where heavy shade is required, or on fallow or waste land. So far *Crotalaria anagyroides* has remained free from attack by scale insects which attacks both *Tephrosia candida* and *Tephrosia vogelli*. Selection work is being started this year on *Crotalaria anagyroides* to try and find a type that will also be suitable as a temporary shade in tea.

S K. Dutta.
Agriculturist.

IV. ANALYTICAL AND SOIL RESEARCH.

I. NORTH EAST INDIA SOIL TYPES, PHYSICAL CONSTANTS :

(a). Keen : Raczkowski measurements have been carried out on all the major soil types of North East India tea areas. The conventional method was used with the difference that gooch type crucibles were used instead of metal cylinders. The soil samples, which were chosen as being representative of the major soil types, were pulverised and sieved before test ; consequently these results tell us nothing of the soil structure factor. Nevertheless the information obtained is useful as being a general average for each soil type.

(b). Sticky point and Index of Texture : Sticky points were determined for the major soil types using the Keen and Coutts technique and the Index of Texture calculated according to Hardy's method. The latter method has been used by certain workers for purposes of soil classification and we think that it would be quite suitable for the North East India Tea areas as a basis for classification.

Sticky point measurement also has significance for cultivation. Although cultivation in tea is not the same thing as that necessary in general agriculture, a fair amount of soil-stirring is carried out in some areas. Also we have come across cases where the soil was in such an unfavourable physical condition that we considered employing some form of soil stirring. In all such cases our view is that any soil stirring necessary, must be carried out when the soil moisture is at a certain optimum value. Other workers have postulated that this is the same as moisture at sticky point and we have obtained some evidence that this applies for our sandy soils.

(c). Soil Structure : Attempts have been made to measure soil structure of plots which have received either different forms of cultivation or widely differing manures, by aggregate analysis, porosity measurements and filtration studies. The first method is not entirely suitable on account of the fine roots of tea which vitiate results but nevertheless we were able to measure the differences beween plots which had been light-hoed and cheeled respectively. On the light-hoed plots, the soil was stirred by hoeing to a depth of 4"-6", about six times per annum between February and November. On the cheeled plots, the same number of rounds as in the case of the light hoed plots was given, but no soil stirring was done, the weeds being merely scraped from the surface of the soil and piled in ridges in alternate rows of tea.

During the current year we propose to carry out aggregate analysis *for plots not carrying tea but which have received different* cultivation treatments. This will give us some idea as to what the actual effects of cultivation are on our sandy soils. The other two methods mentioned have given promising results and will probably be more reliable for soils carrying tea. The whole aim of our investigation is to know exactly what effect different methods of cultivation have on soil structure and also devise ready methods for measuring physical condition of given soils under field conditions.

II. SHADE MEASUREMENT :

Measurement of the intensity of shade trees is quite an important problem in tea and we have two methods in view. The first using a photo-cell and automatic counters would be very convenient but we have not yet been able to get it to work. The second, based on decomposition of a solution of Oxalic acid in Uranyl Sulphate (method by courtesy of Hawaiian Experimental Station workers, full details not published) has been quite successful and has been employed by us to measure the shade intensities of various shade trees and nursery shades. Our technique is to obtain what we call a shade factor, in terms of a chosen standard shade, by, taking the difference in decomposition under a particular shade and in direct sunlight.

III. ROUTINE ANALYSIS :

During the year the following samples were examined—

Soils	...	420
Water	...	21
Manure	...	59

and 122 advisory letters were written to various gardens in reply to their queries.

N. G. Gokhale.
Soil Chemist.

V. TEA PATHOLOGY.

(A) ENTOMOLOGICAL BRANCH.

1. General.

Mr. E. Hainsworth arrived in Tocklai in February of 1947 and during the year was engaged in reopening the Entomological Branch which had been closed since 1940. Most of the year's work has been concerned with problems of immediate practical importance, and in particular the application of new developments in insecticides and acaricides in the control of tea pests. This report briefly reviews some of the results achieved during the year. The experimental records on which the findings are based have already been published in the Station's Quarterly Reports. The latter are in the nature of internal progress reports, and are not circulated to members, but where further information on any experiment is required, a copy of the fuller report can always be obtained on request.

2. Experiments on Tea pests.

2. 1. *Helopeltis theivora* Waterhouse.

A series of experiments was performed at Balisera Tea Estate in the Surma Valley, in which it was demonstrated that DDT was effective in the control of *Helopeltis* (the "Tea Mosquito"). Because of disrupted communications and general transport difficulties only one sample of DDT was received and thus it was not possible to carry out a comparative evaluation of various formulations. The sample examined was a water dispersible powder * containing 50 % of DDT, with the addition of a sticker. It was found to give effective control down to a concentration of 0·125 % of DDT in the spraying fluid, which is the equivalent of 1 lb. of powder in 40 gallons of water. The cost of application, including labour, was found to be between Rs. 15/- and Rs. 20/- per acre. Based on the findings of the experiments and on previous work by Antram in this Department and Rao in South India on the biology of *Helopeltis*, a bulletin has been published on *Helopeltis* control, and circulated to members.

Two main methods of control are advocated.

1. On gardens with an endemic population of *Helopeltis*, a general drenching spray of the permanently affected areas at the concentration mentioned above (1 lb. of powder in 40 gallons) to be applied at the following times :—

Surma Valley	...	...	January and February
Dooars & Terai	...	...	March and April
Darjeeling	...	...	May and June.

2. When an epidemic is spreading through a garden, the topspraying of a barrier ten bushes wide round the affected area, at a concentration of 0·25 % of DDT in the spraying fluid (1 lb. of powder in 20 gallons) followed by a general drenching spray of the affected area at 1 lb. of powder in 40 gallons.

For the present only, the brand of DDT which we have tested † is recommended for use in *Helopeltis* control. There are many obscure high-priced brands on the Indian market and before using any other brand members are advised to consult this Department, giving details of the formulations they propose to use.

The use of Gammexane is not recommded at present since it imparts an undesirable taint to manufactured tea. Non-tainting formulations of Gammexane are being investigated by the makers and these will be tested as soon as available.

2. 2. Red spider— *Tetranychus (Paratetranychus) bioculatus* Wood-Mason.

A severe attack of Red spider throughout many tea districts took place in 1947. It was claimed to be the worst in living memory, and in

* Geigy's "Guesarol" 550 Agricultural Spray Powder.

† Geigy's "Guesarol" 550 Agricultural Spray Powder.

some places persisted many months longer than the normal attack. At Borbhetta the effect of various cultural treatments on the degree of attack by Red spider was investigated, but it is clear that the main factor affecting the incidence of Red spider on an area is the number of active mites which are present in the area at the time when the tea leaf becomes vulnerable to attack, or which reach the bushes at this time by normal methods of dispersal. The relationships between cultural operations and the incidence of Red spider vary with the climatic factors favouring the attack, but some operations, notably any form of soil stirring in the cold weather,–increase the susceptibility of the bushes to Red spider. Again, there is less Red spider directly under shade trees, but this may be a purely mechanical effect in that the silken thread on which the Red spider is dispersed may become entangled with the branches of the tree. The numbers of Red spiders on tea under shade is directly related to the time of coming into leaf, the earliest trees having the least Red spider underneath them. The degree of natural resistance to attack by Red spider on a tea bush varies with the type of bush. In an area of mixed tea severely infected with Red spider, 18000 bushes were examined and 14 bushes were selected which shewed a high degree of resistance. These will be propagated vegetatively during 1948. The inherent resistance was shewn to increase considerably from the dark leaf types to the light leaf types, and it is possible that an immune bush may be found as the search is extended.

A number of acaricides have been evaluated in the laboratory against Red spider, and based on the results of these evaluations, field trials are contemplated during 1948.

2. 3. Looper caterpillar - *Biston suppressaria* :—

In 1947 there was a severe outbreak of Looper caterpillar in Assam. Over 50 gardens were affected. The total area of tea attacked was 7000 acres and the total weight of caterpillars collected by hand from the affected tea was over 250 tons. Subsequent reports indicate that a considerable area of the affected tea has been so weakened that it may die out.

No control measures could be advocated against this insect.

A start has been made in collecting information on the biology, distribution and history of this pest. It appears that it was not known in North East India before 1896, when an "obscure geometrid caterpillar" was sent to the Indian Museum for identification. Soon after 1900 it appeared as a tea pest in Assam, and in about 1920 reached Golaghat. On three occasions since then there have been epidemic outbreaks of the caterpillar which has persisted in smaller numbers in three centres in the intervening years.

The caterpillars were destroyed in large numbers in June and July by a bacterial plague, which undoubtedly saved the situation, since hand collection of larvae, pupae and moths can never be complete. Vigorous work on the control of Looper caterpillar with insecticides and investigation of the possibilities of bacterial cantrol, is contemplated in 1948.

3. Pests of *Tephrosia candida* :

There are three major pests of this green manure plant, all unnamed. Control measures for these have been laid down as a result of small trials. They involve—

1. Apion sp., a leaf-sucking beetle : spraying with aqueous suspensions of DDT.
2. Laria sp., a seed boring beetle : seed disinfestation with carbon tetrachloride.
3. Scale insect (unidentified) : cutting out and burning affected plants.

Where infestation is heavy it is recommended that a more economical measure is to cut out existing *Tephrosia candida* and to replace it with one of the following—

1. *Crotalaria anagyroides*
2. *Tephrosia vogelli African Medeloa*
3. Sunn Hemp.
4. Arahar Dal.

4. Spraying equipment—

The spraying equipment available for use in controlling tea pests is not efficient. Because of the way in which tea is grown, it is necessary to use the Knapsack type of portable hand sprayers, and developments in spraying equipment have largely bypassed such machines. Some manufacturers in U. K. have become interested in the special problems of tea spraying and it is to be expected that prototypes of new equipment will be available for trial by 1949.

E. Hainsworth.
Tea Pathologist.

(B) MYCOLOGICAL BRANCH.

226 specimens were received and reported on. Two tea seed samples, one of which was meant for export certification, were examined.

4 diseased specimens of *Camellia* spp., and 1 *Rhododendron Formosum*, collected by Mr. Kingdon-Ward from the Khasia Hills, were examined. An *Exobasidium*, distinct from *Exobasidium vexans*, (Blister blight), was found on the Rhododendron. Species of *Guignardia* and a *Lophodermium* were found on the *Camellias*. The fungi failed to grow in culture.

Blister blight (*Exobasidium vexans*, Massee).—A severe outbreak of this disease occurred for the first time on tea in South India and Ceylon in August 1946. Specimens of affected leaves received from South India were examined and identified as *Exobasidium vexans* Massee—the same fungus that causes Blister blight of tea in North East India. In February 1947, the Mycologist, at the invitation of the President of the United Planters' Association of South India, paid a short visit to South India in order to gain first hand knowledge of the depredations of the disease and to suggest such control measures as might be suitable under the prevailing conditions. A report was submitted in March 1947.

Black rot (*Corticium invisum*, Petch and *Corticium theae*, Bern.)-A small patch of tea, consisting of 2 plots of 90 bushes each (Plot Nos. 231G and 231H Tingamira), at Borbhetta, was found to be infected by *Corticium invisum*, Petch, in 1946. The number of diseased bushes was too small for use in a properly planned experiment. Each of the two plots was divided into two, one half was sprayed with 0·5 % Perenox and the other half with 0·5 % Perenox plus 0·5 % Alboleum. The number of infected bushes, out of 90 per treatment, was as follows :

	Before spraying (in August 1946	1 year after spraying (in September 1947).
1. Perenox 0·5 %	24	2
2. Perenox 0·5 % Alboleum 0·5 %	34	0

A Memorandum (No. 19) on the Black rot of tea in North East India was written and sent to the press.

K. C. Sarmah.
Assistant Mycologist.

VI. BOTANICAL.

Section I Observations regarding the nature of quality.
II Classification of the tea plants of commerce.
III Vegetative Propagation.
IV Vegetative Clones.
V Generative Clones.
VI New Introductions.
VII Ancillary Activities.

Appendix—Tea breeding schemes.

I. OBSERVATIONS REGARDING THE NATURE OF QUALITY :

(1) The incidence of a pathological symptom designated as *Grease Spot* (G. S) has been the subject of study in the field. Grease Spots are slightly raised localised areas rather like a blind wart on the under surface of the leaf, and translucent when viewed by transmitted light. They are characterised by abnormal cell divisions and the destruction of chlorophyll. In this sense they are regarded as pathological. It does not follow that they are caused by a foreign organism and at the moment we have no clue as to their origin. *

(2) On limited data, which must necessarily be the subject of a future report, the following working hypothesis has been propounded. Grease Spot is

* This work occurred as an integral part of the breeding programme. All our date has been handed to the Plant Pathologist who has been of the greatest assistance in the course of this work.

transmitted by the female (the question of pollen transmission being left open) and a high percentage of her progeny are markedly chlorotic. This chlorosis and Grease Spot are both regarded as symptoms of a common or closely related condition. The chlorosis is associated with a high level of quality in the progeny which quality need not be present in either of the parents. It appears that the factors of which Grease Spot is a symptom, *when present in the right plant*, are responsible for the formation of " quality "— *ie* Grease Spot, or the basic factors of which Grease Spot is a symptom, in conjunction with the right complement of genes can be responsible for quality. It would not follow that Grease Spot is the only factor operative in the production of quality, but it is thought to be an important one and it may be responsible for the formation of " quality " of a qualitatively different nature from other levels of " quality ".

(3) The chlorotic progeny of a Grease Spot female are distinguished not only by a yellowness (equivalent to " lightness, " and equivalent also to chlorosis) of their young leaves but also by a marked breakdown being particularly associated with a drop in temperature and rise in insolation at the end of the monsoon.

(4) *Quality plants in this instance were associated with a propensity for a biological breakdown of chlorophyll in the living tissues.* A breakdown of chlorophyll in the living plant due to any conditions may prove to be an important causal factor in the production of quality ; thus heavy shade would tend to reduce quality and a sudden drop in temperature would cause it to rise.

(5) Reference to the Botanist's Quarterly Report for June 1946 and the Botanist's Annual Report for 1946 will show that work by members of different branches of this Station over many years has proved quality to be associated with both lightness of the leaf and kind of plant. These observations date from Dr. Wellensiek's tour in N. E. India in 1937 when he drew our attention to the phenomenon subsequently described by the Botanist as *dichromism*— *ie* a great discrepancy in the tone of mature and immature leaf, associated with a much slower rate of attainment of the final mature tone by the leaves of a dichromic plant. Observations along these lines are extensive and complicated and are beyond the scope of this report : all have a bearing on quality. We are indebted also to Mr. R. M. Pizey of Monabarie T. E. for relevant observations which led to the investigation by Mr. Harrison and Mr. Macgregor in 1941 (see Quarterly Report for June 1946). Attention is drawn also to a statement by Dr. Roberts made to the London Advisory Committee in England in 1947, in which he suggested that quality may be associated with the presence of virus disease. Similar ideas were advanced by Mr. F. S. Benton in 1939 or earlier.

(6) Whilst the observations referred to in para (5) have shown a *general* relation between quality and tone, this relation leaves by far the greater number of particular cases to be explained : the relation indicates one of the factors responsible for quality but not all of them ; the kind of the plant (*ie*. its genotype) undoubtedly is one other factor. High quality does occur in plants the mature leaf of which is quite dark and in this connection reference may

be made to an article by Wight and Barua in the Tropical Agriculturist XCIII (1) 4. 1939. Further discussion is beyond the scope of this report but attention is drawn to the fact that a plant may be either " dark " or " light " judged on mature leaf, it may be *dichromic* or not, and " lightness " may be either innate or pathologically produced. Innate light leaf is thought to go with low quality as in the well known case of Lushai tea : this same innate lightness of leaf may crop up (segregate) in any population.

(7) Should the ideas regarding Grease Spot which are advanced in this report prove to be substantiated by further investigation, then interesting and unusual methods of breeding would become possible. Grease Spot in itself does not mean quality but is regarded as a potential donor of extraordinary quality when used in conjunction with the correct pollen. Extraordinary vigor is known to be pollen transmitted and usually goes with very low quality. Suitable mating—possibly extra-specific—and involving a Grease Spot female might result in the combination of quality and vigor. Pollinations on these lines are in hand but it will be some years before the results are known

(8) In closing this section of the report a word of warning is necessary regarding the activities of the practical man in the field of amateur selection.

In the case of generative clones *ie.* clones used for seed production—we have found matings between pairs of selected light leaf individuals which possess quality, to be difficult, to have a low index of compatibility, to result in poor seed yield, and to produce seed with relatively poor germination : it is possible that the progeny will show up badly in respect of crop yield. Some of these factors are known to commercial growers of light leaf seed. In a commercial bari where no two trees are exactly alike and Mass Selection is practised, a point is reached beyond which no further decline is possible along the lines indicated. But in a bi-clonal bari it would be easy for an amateur to select the parents to the point of extinction of the progeny.

In the case of vegetative clones (*ie.* those intended for leaf production) it is considered that a primary selection on the basis of light leaf—and particularly on the basis of a light young flush—could often give a negative bias in respect of vigor, though this is not to say that *innate* light leaf as a class have low crop yield. Vigor is of paramount importance in a vegetative clone and the primary selection should be for this factor alone and completely ignoring the kind of leaf. There will be sufficient variation amongst the plants so selected, for desirable cup characters to be picked out by the direct and only satisfactory trial of manufacture. The matter has been dealt with at length in notes under this Branch Case No. B 30, copies of which will form the first part of Botanical Memorandum No. 66. It is intended to submit this Memorandum to the Calcutta and London Scientific Sub-Committees as an appendix to Botanical Branch Report for March 1948. As the work is incomplete and the memorandum may need amendment in the near future, it is not possible to put it in print, but there is no objection to its limited circulation in typescript. It is proposed to put some of the practical aspects of Botanical Memorandum No. 66 in print after the Botanist's return from Home Leave in 1948.

II. CLASSIFICATION OF THE TEA PLANTS OF COMMERCE :

(1) Reference to the Bot. Branch Report for the Quarter ending June 1939 will show that an initial classification of plant types was arrived at before the outbreak of war. Work along these lines ceased in June 1939. The Botanist was on Home Leave for the remainder of 1939. Work in 1940 consisted entirely of long term organisation of the Breeding Programme which was thus enabled to continue during the war period in the hands of the Assistant Botanist. This year work on classification has been resumed.

(2) The classification referred to above was based on a limited number of simple indicator characters and was an application of the methods of *gene ecology* to agricultural material. The eight classes of plant designated by the symbols

A. AN. NA. N.NB. BS. B. BB.

may be called agrotypes in the nomenclature proposed by Gregor (1933. Annals Applied Biology XX (2) : 205-219). We are indebted to Dr. Gregor for a great deal of advice and assistance given to the Botanist personally during his visit to Edinburgh in late 1939.

(3) The symbols used to designate the agrotypes no longer have any significance but they are retained because the original field records are in this form : any other series of symbols could be used.

(4) The series of types form a *Cline** in respect of the chosen indicator characters, this cline extending from plants of undoubted Assam origin to plants of undoubted China origin. The presence or absence of characters other than those chosen, and indicative of origins other than Assam and China (for example, origins near to the Equator in the southernmost point of natural distribution) was ignored. Such characters were not relevant to the investigation in the first place but necessarily will be the subject of further work.

(5) The terms "northerly" and "southerly" used in the Botanical Branch Report for June 1939 and in the Tropical Agriculturist XCIII (1) : 4. 1939, as indicative of the trend along the cline, should be abandoned. The terms positive and negative are now used, negative referring to the characteristics associated with Assam origin and positive to the characteristics associated with China origin. The term "southerly" properly belongs to characteristics associated with an origin in French Indo-China.

(6) Our studies have been made on the tea of commerce and have interpreted as far as possible in terms of known geographical origin. It appears that there are two main axes of geographical distribution, one approximately east to west from Assam to China and passing through a point Lat. 22 N. Long 98 30 E, and the other from north to south from the same point to French Indo-China (Cambodia). These two axes roughly correspond with the valleys of the Brahmaputra, Irrawady, Salween, Mekong and Yangtse-Kiang.

* Huxley 1939, Nature 3587, 142.

(7) Since 1939 the cline of agrotypes has been studied by all Branches of the Station. The cline is undoubtedly valid in respect of characters other than those on which it was founded : the seriation of agrotypes is a seriation which permits of linear and curvilinear regressions to be fitted to the incidence of characters other than those used in defining the agrotypes. Indeed it is surprising to find that such diverse characters as floriferousness, potash content of the leaf and incidence of virus symptoms, when independently determined by different Branches, can be logically interpreted by the seriation of agrotypes. It would not follow from *a-priori* reasoning that seriation in respect of an indicator character achieves a satisfactory seriation in respect of other characters. The chosen characters must be of fundamental importance.

(8) The chosen characters were vegetative and were applied to all the individuals in a given collection of representative populations. The data is in the Botanical Branch Report for June 1939.

(9) During 1947 the same populations were studied on the more usual taxonomic lines. For this purpose we isolated the most extreme variants in respect of characters accepted as valid by orthodox taxonomists, particular attention being paid to floral characters. These isolated types alone were studied. They were three in number and to have originated in three distinct geographical sources—Assam, China and French Indo-China (hereafter referred to as *Cambodia*, giving the symbols A, B and C for source of origin). Further study showed that these three types, when considered independently, are of at least sub-specific rank. When viewed independently and separately from the variants of agriculture, many Botanists would regard the three types as distinct species. Having established the criteria of these types we find, on referring back to the variants of commerce, that some characters of one or more of the three types are to be found in all the tea of commerce.

We have therefore come to the conclusion that the tea of commerce is a mixture of hybrids between at least three distinct species (or sub-species).

(10) At the moment, and without consulting the International Rules of Nomenclature, our interim designations of the classes recognised are

Assamica—the tea of Assam
Cambodia—the tea of French Indo-China
Sinensis—the tea of China.

(11) Material collected in 1917 by L. O. Wilson in the approximate location of 'Nmai Hka (?) between the Makha and Salween rivers in the region Lat. 26°-27° N, Long. 98°-99° E. was available for study.* This was additional to the material referred to in the foregoing paras. The one surviving plant raised from seed collected from trees regarded by the collector as possibly separate from "tea" (altitude 7, 000 ft.) proves to be a distinct species of *Camellia*, so far unidentified but very close to "tea". This is

* The exact location has been lost and as far as is known was not divulged by the collector.

interfertile with tea and was found growing in association of tea. It is extremely unlikely that hybridisation would not occur freely under wild and semi wild conditions, and conditions of local village cultivations such as have been the source of origin of all of the recent tea of commerce. We refer to this *Camellia* tentatively as — Irrawady. Its cup characters are highly detrimental. Experimental hybrids with — *Assamica* are in existence but have not yet been studied. The hybrids are characterised by extraordinary vigor and to the layman are quite indistinguishable from tea.

(12) Tocklai is deficient in *Sinensis* types and further collection will be necessary. This deficiency is serious from the aspect of breeding and is proving a hindrance to the work of the Biochemist and Plant Pathologist. Collection will be necessary in those parts of India where tea plants are known to have been imported direct from China by Robert Fortune and have subsequently been abandoned without any attempt at " improvement " with material from Assam Suitable localities were examined by the Botanist during his Military Leave in 1945. These areas were inspected by Robert Fortune after he imported the material from China and copies of Fortune's reports are still in existence. Although the last of these areas was abandoned between 20 and 30 years ago many of the plants are still in existence and the superimposed factor of intensive natural selection over such a long period is of very great value.

(13) We have found by personal experience of extreme *sinensis* imported by the Botanist, and by Mr. Kingdon-Ward prior to the last War, that this material is unsatisfactory and difficult to maintain in the plains of Assam. A sub-collection in the care of the District Advisory Officer at Darjeeling will be necessary. With this end in view the Assistant Botanist has investigated methods of pollen storage and we are now able to store viable *assamica* pollen up to three weeks—*sinensis* pollen is less viable but could be transported easily to any part of India.

(14) The planters' distinction between "true China" and "China Hybrid" is very sound and quite valid. *Sinensis* characters occur all through China Hybrid but so also do *assamica* and *cambodia* characters. Segregates which can be regarded as typical *sinensis* are few and far between. In addition, other characters occur which cannot be related to any of the four species (sub-species) so far recognised. A form with a pink blush to the petals is not uncommon and it should be relatively easy to breed out a form with distinctly red or pink flowers—a character not recognised in any form of tea. An observation on this point comes from Mr. E. J. Nicholls, C. B. E. who has personally described a pink flowered tea bush.

(15) These observations suggest that China Hybrid is the descendent of extra specific crosses possibly involving more species than we have recognised so far. It is not likely that the amount of variation observable in China Hybrid is due to crossing after its arrival in India and still less likely to be due to crossing with *assamica*. Most China Hybrid is not more than one generation and some of it probably no generations removed from seed collected in China.

It is thought that Robert Fortune when he toured the tea districts of China collecting seed for India was " sold a pup " by the Chinese. The practical certainty that wide crosses have occurred in regions between the valleys of the Brahmaputra and the Yangtse-kiang is indicated in para (11) above.

(16) Dr. Wellensiek has stated in his account of the tea of N. E. India that the " China Hybrid " forms surviving in Darjeeling are probably the the result of crossing outside the species which has been accepted under the current designation of *Camellia sinensis* (L. O. Kuntz).

(17) A word of warning is necessary here. These statements do NOT mean that China Hybrid nor the tea of Darjeeling is to be uprooted. The crossing may have enhanced the commercial value of the tea for the particular district. In point of fact, we are now engaged at Tocklai in making more crosses outside the species.

(18) During 1947 we examined a local population of " China Hybrid " of considerable age and found that flowers of 3 % of the plants were characterised either by aborted ovaries or aborted anthers. Approximately 50 % of either case occurred. In some cases the rudiments of the ovary could be detected only with a hand lens. In other cases the majority of the anthers were certainly non-functional. This finding would be regarded by cytologists as a certain indication of extra specific crossing.

(19) In the foregoing paragraphs mention has been made of a cline of agrotypes and also of specific distribution. The two methods of classification are fundamentally different and cannot be directly compared, though a general relation exists. This is beyond the scope of an annual report and the whole subject must necessarily be dealt with in technical communications. The object of this report is to indicate the nature and trend of our work, leaving the technical evidence for separate and later consideration. Many methods of classification may co-exist and each be equally useful in its own sphere—for example one has to consider classification on compatibility and classification on growth habit such as " single stemmer " and low branching types. As long as scientific investigation of the tea plant exists, so long will the problems of classification continue : classification can never at any time be final. But to be of any use in Agriculture ascertained characters of the plant, whatever they may be, must be related to characters observable by the eye and owe their importance to their behaviour when propagated, either by vegetative or generative means, so that the ultimate utility of any classification is dependent upon botanical science.

(20) In closing this section of the Annual Report very special mention must be made of Mr. and Mrs. A. C. Tunstall. The whole work of the Botanical Branch, particularly in the sphere of classification, is based upon an extensive collection of tea plants grown from seed gathered from commercial *baries* all over N. E. India and from wild sources in the Patkoi and Lushai Hills, in the Triangle and from French Indo-China. Mr. Tunstall was responsible for the collections from far afield and Mrs. Tunstall personally arranged and

supervised the planting in 1918 of a representative collection of commercial brands, many of which have now passed out of existence in their original sources. This collection is unique — probably in the whole of S. E. Asia. In so far as subsequent research has proved of value, the Industry owes a great deal to the energy and foresight of Mr. and Mrs. Tunstall. It is perhaps to be regretted that a botanist was not included earlier on the staff of the Station.

III VEGETATIVE PROPAGATION.

Periodicity of cutting growth

(1) Irrespective of wide differences in the time of taking the cutting, there is a marked tendency for all cuttings to form their first shoots within a relatively limited period : for all practical purposes the majority of a population of cuttings taken at various times all become liftable plants at a common time. Those which lag behind the bulk of the population are not worth bothering about in large scale . practice when beds have to be cleared and more work undertaken.

(2) It has been found that cuttings which are planted mid April to mid May will form their first shoots by the end of September and are then liftable plants. (Root formation precedes shoot formation). More than half of the *surviving* cuttings will form a flush of shoots by the end of September. Of the balance, many will be rooted but will not shoot until the end of the following March.

(3) It is known that the majority of cuttings planted after mid-June begin to shoot in March. Thus, cuttings planted in September and October will be ready as soon as the bulk of those planted in the latter part of the preceding June. The March flush involves a very high percentage of the surviving cuttings and the balance of those remaining without any shoots in March is low.

(4) Thus, two natural periods of taking cuttings exist. One period must pass into the other. We have insufficient data respecting the nature of the transition. However it is likely that cuttings taken between mid-May and mid-June will give mixed results in terms of growth response and time of initial flushing. This is the subject of further investigation.

(5) The current practice is to clean prune a tea bush which has an orthodox flatt opped frame. The stems are then allowed to grow unfettered and without tipping or plucking. At the time of taking the cuttings the plant is again clean pruned leaving half an inch of the basal growth of the new stems. The long stems removed by pruning are carried to the propagating beds and there made into single node cuttings. Taking cuttings is thus synonymous with pruning and stimulates the bush to produce suitable shoots for the next time of taking cuttings. The practice of taking cuttings twice per year was instituted by the Senior Advisory Officer (Mr. Macgregor).

(6) Pruning in March, April and May will result in shoots in a satisfactory state of growth for the production of cuttings in September. Pruning in September will result in a smaller crop of shoots, but in a satisfactory state

of growth for the production of cuttings in the following April and May. The percentage success of cuttings is highest about April and falls off gradually towards the end of the season. The number of cuttings which can be made aviaable in the autumn is greater than that which can be made available in the spring. These factors will be discussed in detail in Botanical Memorandum No. 67 as an appendix to Botanical Branch Report for the Quarter ending March 1948. Their practical aspects will be the subject of a printed handbook now being prepared by the Agriculturist.

(7) The two "natural" periods of taking cuttings are associated with the Vernal and Autumnal equinoxes.

(8) The natural foliar periodicity of an unpruned tea plant shows a succession of flushes of new elongation growth involving less and less shoots towards the end of the season until, in most types, the last buds break in early September.* The tree is thereafter dormant until a mean date which coincides exactly with the vernal equinox ; then very many of the buds on the tree have the potentiality of elongation growth and a new cycle begins, the first flush of which is the greatest. We have designated the annual re-birth of buds at the beginning of a new cycle as the *climacteric*.

(9) The relations between innate foliar periodicity of the mother plant and the periodic behaviour of cuttings taken at different times is of great interest. It will be appreciated that these investigations have applications in the field of pure science in that the growth of single node cuttings such as are being used, indicate the potentialities for growth possessed by a single bud when it is removed from its position in the individual and thus freed from the competitive influence of other buds on the plant.

Propagating Sheds.

(10) *Lath frames* of a standard size, as used by the Indian Forest Service and in commercial horticultural practice in the U. S. A. have been investigated. These are raised only a few inches from the ground (of the order of nine inches) and the method of use is very similar to that for glazed lights and cold frames in temperate climates. Our conclusions to date are given in Botanical Memorandum No. 67 referred to in a preceding paragraph. Practical recommendations will be given in a memorandum now being prepared by the Agriculturist. Illustrations of lath frames in use are to be found in Audel's Gardeners and Growers Guide Vol. IV. New York. 1944.

IV VEGETATIVE CLONES—Clonal Gardens.

Ref. Botanical Branch Annual Report 1945 para (37)

(1) The dangers inherent in the extensive use of a limited number of vegetative clones are very real and must be constantly borne in mind.

(2) On the other hand the certainty of an increase in crop production – estimated to be of the order of 25% — without any loss in the value of cup characters, makes one seriously consider whether the risk is not justifiable, particularly in view of recent advances in plant protection.

* Other types from near the Equator, show a more pronounced autumnal growth.

(3) We consider that the use of at least ten clones on any one garden and a different ten clones on each garden would sufficiently reduce the risk to make the proposition a worth while commercial venture.

(4) This involves a very large number of vegetative clones — more than Tocklai can produce. But the material necessary for their selection is already in existence. With suitable training the staff of many Gardens are capable of doing this selection, particularly if the matter is undertaken on an Agency House basis and arrangements are made for miniature manufacture and subsequent tasting by a centrally located taster.

(5) Replanting by means of cuttings is no more difficult than replanting by means of seed. It necessitates two things — experience and sufficiently large nucleus clones. Both take time. After the initial time lag the merits and demerits of the method can be assessed directly in commercial practice.

(6) No further progress can be made and no firm decision reached until the initial time lag is overcome. The matter has already passed the experimental stage. If the whole industry work forthwith at top notch on quite a limited number of vegetative clones then the danger point cannot possibly be reached under ten years: meanwhile, most valuable information will have been obtained.

(7) We thoroughly agree with the Senior Advisory Officer (Mr. Macgregor) that the most pressing need of the Industry in this field is men experienced in vegetative propagation and also sufficiently large areas of clonal tea to make direct commercial trial possible.

(8) This work should NOT be dependent upon a limited number of vegetative clones distributed from Tocklai. The possibilities of advance are much greater and much safer if the matter is tackled on an Agency House basis. With this end in view Botanical Memoranda Nos. 66 and 67 will be appended to the Botanical Report for March 1948. For the present these memoranda can have a limited circulation only in typescript. It is planned to put selected parts in print at a later date.

(9) The whole matter will be dealt with in detail at the 6th Annual Conference and will be reported in the Proceedings.

(10) Tocklai vegetative clones must be regarded as supplementary to material selected by the Industry itself. We plan to release five new vegetative clones at intervals of five years. This statement modifies those made in Botanical Branch Report for Sept. 1947. Due to war conditions our trials are incomplete and we have nothing which can be regarded as *tested* clones, but rather than delay matters any further we have decided to release immediately (*ie* as soon as the material can be propagated) five of our best clones on the understanding that these are not tested but appear to us as likely to be of value under mid-Assam conditions. Some may do well elsewhere, some not.

(11) We propose to make a charge for the material.

(12) In connection with the considerations outlined in the foregoing paras reference to the Botanical Branch Report for Sept. 1947 and to the Proceedings of the 6th Annual Conference when published, is essential. These sources contain relevant details which are too lengthy to include in an Annual Report.

(13) Owing to the time taken in propagation most of the clonal plants for release will not be ready until early 1949. Some plants of clone No. 1/7/1 (dark leaf Manipuri with good quality) will be ready by June 1948 but release may be held up pending decisions on policy by the Scientific Sub-Committee of the I. T. A.

(14) Further para (6). If the introduction of vegetative clones now proceeds apace, neither the saturation point nor the danger point are likely to be reached before *clonal seed* (the product of generative clones) becomes available. Clonal seed will at first be limited in amount but it gradually increasing use will offset the dangers inherent in the excessive use of vegetative clones, from which the industry in the meantime should have reaped material benefits.

V. GENERATIVE CLONES.

These are to give clonal seed. The production of generative clones is the object of our breeding schemes. Details of the work are given in the Botanical Branch Annual Report for 1945. Progress to date is given in tabular form in tables I and II of Appendix to this report.

VI. NEW INTRODUCTIONS.

Samples of approximately 150 seeds from 60 commercial *baries* were sown at the end of the year. These are representative ungraded samples of seed as produced in the *bari* and were obtained through the collaboration of the Calcutta Agency Houses. Our best thanks are due to all concerned for a splendid response to our appeal. The material is primarily for technical studies based on seed size but it is our intention to submit confidential reports to all concerned, particular attention being paid to the correct seed size for the particular *bari* and the percentage of waste seed produced. Relative crop yield and manufacturing characters are to be investigated with the object of informing the owners of these *baries* of their relative overall value.

The samples of seed so far received represent a fraction only of the existing *baries*. It is our intention to make these trials a yearly service to seed growers ; but, due to pressure of work in other directions and to lack of fencing and heavy financial commitments in other directions it will not be possible to continue the scheme during 1948, and the further collection of seed is temporarily shelved until 1949.

VII. ANCILIARY ACTIVITIES.

In addition to the main problems referred to in preceding sections, various ancillary investigations have been undertaken. None of the data relating these has been examined in detail at the time of writing. In some cases it

will be possible to draw conclusions in the near future, in other cases a report must await the collection of further technical data. The more important of these subsidiary investigations are briefly described in the following paragraphs, though the ideas expressed therein are naturally subject to further investigation and, possibly, modification.

(1) *Seed size and density*. Both these characters show a significant interaction with source of pollen and must therefore be heritable. It should be possible to select a strain (or jat) of tea which produces 100% " floaters " or 100 % small seed. The value of tea seed is judged neither by the size nor the density of the seed, but by the kind of plant which the seed produces. If a marked change in the size or density of the seed is required then this should be implemented by changing the trees in the *bari* and not by grading the seed to an arbitrarily chosen standard. The seed as produced in the *bari* determines the optimum standard for grading and on our present knowledge there is little point in selecting seed " against the grain " of the *bari*—it is anyway uneconomic to do so.

(2) Other studies indicate that seed size is linked with varietal characters of the leaf.

(3) Work discontinued in 1940 showed time of dehiscence to be associated with speed of germination and gave a strong indication that these two factors are associated with varietal differences and geographical distribution. Owing to the great size of tea seed, technical work along these lines is comparatively easy.

(4) The greater the percentage of flowers to set seed the greater is the capacity of the seed to germinate. There appears to be some relation between floriferousness, " set " and germination, though the nature of the relation is probably different in different species and sub-species.

(5) The balance obtaining between foliation and floriferousness, in connection with the factors indicated above, is under investigation.

(6) When judged as the sole pollinator of a number of females, some tea plants are notably *potent* and predominantly male. Conversely, when judged as the sole receiver of pollen from a number of different males, then some tea plants are notably *fruitful* and predominantly female. Many indeterminate intergrades occur but it seems likely that, in very general terms, extremely good pollinators are poor females and *vice-versa*. These considerations may prove to be distinct from the hybrid sterility recorded in Section II para (19). They indicate a tendency towards a *dioecious* condition ; in this connection it is of interest to note that the related genus *Eurya* is *dioecious*.

(7) *Self fertility*. This is a somewhat variable factor and has resulted in partially conflicting statements being recorded in the literature. The general situation is as recorded by Wight and Barua in the Tropical Agriculturist XCIII (1) : 4. 1939. It now appears that the more *positive* the characteristics of the plant (*vide* Section II para 5) the greater is the self fertility

APPENDIX TO BOTANICAL BRANCH—ANNUAL REPORT 1947. TABLE I.

CURRENT METHODS OF TEA BREEDING — Tocklai Experimental Station.

1. Selection prior to breeding operations based on the intrinsic merits of the individual (including its likely breeding behaviour). The first selection may be described as *Bi-parental*.

   A. Matings with the object of producing GENERATIVE CLONES. (Vegetative clones as a secondary consideration).

   Biclonal seed garden intended. ... ...
   Pollination mechanically controlled.
   Material NOT spatially isolated.

   (1) Selfing. Possible only as a secondary long term policy.

   (2) Matings between closely similar individuals : tantamount to inbreeding and may necessitate a long term policy. Known to improve uniformity of leaf type.

   (3) Matings based on relative dominance within a species. Necessitates at least a good idea of possible breeding behaviour.

   (4) Matings between individuals showing differences of a specific magnitude.

   In items (1) to (4) the deliberate introduction of the pathological symptoms designated as Grease Spot (G. S.) has to be considered.

   Multiclonal seed garden intended ... ...
   Pollination NOT mechanically controlled.
   Material spatially isolated.

   (5) Natural random matings between a number of chosen individuals. No further technical work along these lines is contemplated but the method may be of practical utility for the production of more immediate results of rather limited value.

   B. Matings with the specific object of producing VEGETATIVE CLONES only.

   (1) The criteria determining the choice of the parents are extreme vigor and extreme ease of propagation. Similarly of type and general breeding behaviour can be ignored. A large F_1 is essential for the selection of vegetative clones. As extraneous sources of pollen are of no particular importance it is necessary neither for pollination to be mechanically controlled nor for the material to be spatially isolated.

2. Selection prior to breeding operations dependent on the choice of one individual based on the nature of its progeny ; the progeny being produced naturally by a limited number of pollinators which are fixed in position with respect to the female. The first selection may be described as *Maternal*.

   A. Matings with the object of producing GENERATIVE CLONES.

   (1) Subsequent breeding is with the object of choosing the best pollinator from amongst the trees in the immediate vicinity of the female. The evidence indicates that these are limited in number. The method necessitates the pre-existence of mature seed bearers but unlimited amounts of such material are available for study.